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Abstract: Measuring epistemic beliefs is challenging from a conceptual as well as a methodological point of view. Conceptually, it is hard to distinguish between naïve and sophisticated beliefs, and methodologically, common statistical techniques yield inconsistent results. In response to these challenges, a new instrument to measure high school studentsô epistemic beliefs was designed and validated. The 55-item instrument contained three scales (absolutism, multiplism, evaluativism), that reflected different stages in epistemic development (Kuhn, 1991; 1999), moving from naïve to sophisticated beliefs. Rasch analysis was used to analyze the data. The analysis confirmed the existence of the three scales with moderate reliability coefficients.

Introduction

Epistemic beliefs, or learnersô beliefs about knowledge and knowing (Hofer & Pintrich, 1997), have received much attention in the learning sciences. The influence of epistemic beliefs on learning is well-documented (e.g., Muis, 2007; Schommer, 1990), but measurement of these beliefs is a challenge, from a conceptual as well as a methodological point of view. It has been argued that disappointing results should lead researchers to question not only the instruments they use, but also the underling theoretical frameworks as well as assumptions of psychometrics (Duell & Schommer-Aikins, 2001). Aim of this study was to do just that. A new measure of epistemic beliefs for high school students was designed and validated using a modelling technique with promising properties.

Conceptual issues: Sophistication of epistemic beliefs

An important issue in studies on epistemic beliefs concerns the level of sophistication of such beliefs. In many theories of personal epistemology, sophisticated learners are seen as independent and active information seekers who make up their minds independently from authorities. However, most judgments about knowledge claims are not based on personal experience, but rather on information acquired from other sources. Therefore, relying on experts does not necessarily reflect less sophisticated beliefs (Bromme, Kienhues, & Stahl, 2008; Elby & Hammer, 2001). Indeed, previous work has shown that believing in knowledge as personal construction rather than relying on experts may not always be an adaptive strategy in complex reading tasks, especially when readers lack prior knowledge (Bråten, Strømsø, & Samuelstuen, 2008). Others have argued that believing in scientific knowledge as tentative and evolving ï which is typically considered to reflect sophistication as well ï does not correspond to reality in some scientific domains (Elby & Hammer, 2001).

Developmental, or stage models, of epistemic beliefs focus on the development from naïve to sophisticated beliefs and may therefore provide a solution to the challenges with respect to the issues of sophistication described above. An example is the model by Kuhn (1991), in which three stages are distinguished: Absolutism, multiplism, and evaluativism. People at the absolutist level see knowledge as certain and absolute, either transferred by experts or from direct observation. At the multiplist level, which becomes prevalent at adolescence (Kuhn, 1999), people become aware of the uncertain and subjective nature of knowledge and knowing. However, this awareness overrules any objective standards for the evaluation of information. As a consequence, all opinions are deemed equally valuable and right. At the evaluativist level, both previous stages come together. Uncertainty is acknowledged, but without ignoring the importance of evaluation of knowledge claims. That is, two positions can both be right, but one can be better supported by evidence and argumentation, making it more valuable. This makes that evaluativists are considered to have the most well developed epistemic beliefs (Nussbaum, Sinatra, & Poliquin, 2008).

Methodological issues: Instruments and analysis

These conceptual issues are directly related to measurement of epistemic beliefs. In paper-and-pencil instruments (e.g., Schommer, 1990) high scores on measures are interpreted to reflect sophisticated beliefs, regardless of stage of epistemic development. More importantly, it has been argued that research on epistemic beliefs is not based on a strong psychometric foundation (DeBacker, Crowson, Beesley, Thoma, & Hestevold, 2008). Validation of epistemic beliefs questionnaires is typically done with factor analysis of Likert-scale data (Wood & Kardash, 2002), but it has proved difficult to replicate the factor structures of widely used instruments

across samples (Clarebout, Elen, Luyten, & Bamps, 2001; DeBacker et al., 2008). Replication and validation studies have also shown large amounts of error variation and low reliability coefficients (DeBacker et al., 2008).

Therefore, new instruments that can distinguish between sophisticated and naïve epistemic beliefs are necessary. However, stage models of epistemic development are typically based on interviews (Hofer, 2004). Such epistemic interviews have the advantage of being capable of capturing beliefs regarding the source of knowledge and justification for knowing, with which existing questionnaires generally have difficulties (Hofer, 2004). However, although such interviews can provide valuable and detailed insights into learnersô epistemic development, the use of paper-and-pencil instruments enables researchers to include larger numbers of participants in their studies and to link epistemic beliefs to learning outcomes (Hofer & Pintrich, 1997). An existing paper-and-pencil instrument that does distinguish between absolutists, multiplists, and evaluativists was designed by Kuhn, Cheney, and Weinstock (2000). This instrument consists of 15 items in which two contrasting statements are described. Participants have to answer the question whether only one could be right (absolutist), that both can be equally right (multiplist), or that both can be right, but one more than the other (evaluativist). However, this answering structure makes it difficult to assess nuances.

Research aim

Although others have attempted to resolve measurement problems by coming up with new or adapted instruments as well (see DeBacker et al., 2008), use of accurate modelling techniques is equally essential. Therefore, a novel approach was taken validating the instrument with a more advanced model than factor analysis: The Rasch model (Rasch, 1960). The Rasch model can assist in modelling invariant, test- and sample free, interval person and item measures. If raw ordinal person responses on sets of items composed of Likert scales fit the Rasch model, the model can mathematically transform the ordinal measures into interval measures for persons and items. The model positions persons and items on the same interval scale, making a distinction between items that are easy or difficult to endorse. As such, this can provide additional information on what epistemic beliefs make individuals more sophisticated and which ones do not. These are important advantages over factor analysis, making Rasch modelling a very accurate analysis method.

Method

Participants

Participants were 509 high school students from 11th grade (257 boys; 252 girls, M_{age} = 16.64 years, SD = 0.68) from five schools for pre-university education in the South of the Netherlands.

Instrument

A Dutch-language questionnaire was developed based on the stages of absolutism, multiplism, and evaluativism. It was aimed at dealing with (conflicting) scientific claims and information, and with scientists in general. Items were partly based on existing materials (Conley, Pintrich, Vekiri, & Harrison, 2004; Schommer, 1990; Schraw, Bendixen, & Dunkle, 2002; Wood & Kardash, 2002), either in original form or modified, but also featured newly developed content based on theories of epistemic development models (e.g., Kuhn, 1991), and a pilot study among Dutch high school students. The questionnaire consisted of 55 items, of which 19 were hypothesized to reflect absolutist beliefs, 19 multiplist beliefs, and 17 evaluativist beliefs. Participants rated their agreement or disagreement on a 6-point Likert scale (1 = completely disagree, 6 = completely agree). Table 1 presents a number of sample items for each scale.

Table 1: Sample items per level, translated into English from Dutch

Absolutistist	Multiplistist	Evaluativist
By now, scientists know everything there is to know	Personal opinions are just as valuable as scientific knowledge	I always wonder on which information scientists base their conclusions
I find it unreliable when scientists give contradictory information on a particular topic	Scientists will never know anything for sure, no matter how hard they try	You only have the right to speak when you know very much about a particular topic
Studies that do not provide clear conclusions are useless	I do not believe that something can be proven indisputably	What is right in one situation, does not need to be so in another
A single study is enough for scientists to get a good impression of a particular issue	Scientists will never agree with one another	I attach much more value to research data than to personal experiences and ideas

Procedure
Participants filled in the paper-and-pencil questionnaire during regular class hours at their schools. They were given a full class hour to complete the questionnaire, and were explicitly requested to fill it in individually and honestly. Participation was made compulsory by the schools in order to avoid convenience samples.

Analysis
The Rasch polytomous "Grouped response-structure" model (Rasch, 1960; Linacre, 2009b) was employed to construct Rasch interval measures for the epistemic beliefs. Data analysis was performed in WINSTEPS (Linacre, 2009a).

Results

Conclusion and discussion
The analysis showed that the three hypothesized dimensions of absolutism, multiplism, and evaluativism could be distinguished. Reliability was moderate for the three separate dimensions, and satisfactory for the entire epistemic beliefs scale. However, in the current study the person internal consistency measures of scales with only two or three categories came up to similar levels as previous instruments with more categories. Fewer categories always lead to lower person reliability estimates. Hence, even though internal person consistency measures are still modest due to category loss, the current study with the Rasch model has provided the insight that respondents do not distinguish more than two or three different categories in the items. Consequently, although person reliability coefficients are not yet sufficiently high, the use of Rasch measurement rather than exploratory factor analysis is a step forward with respect to measurement and construct validity. It should also be kept in mind that internal consistency does not necessarily imply unidimensionality, and that reliability estimates may also have been lowered due to the relatively homogenous sample in the present study (cf. Wood & Kardash, 2002). However, item reliabilities were very high, suggesting replicability of the item ordering across comparable samples.

There was a weak correlation between the multiplist and evaluativist scales, and between the absolutist and the evaluativist scales. This implies that the different levels may not necessarily reflect separate stages, as suggested by Kuhn (1999) and other stage models, but rather reflect a certain degree of multidimensionality (cf. Schommer, 1990). However, these findings seem to support the notion that evaluativist beliefs are theoretically related, in part, to the absolutist and multiplist levels.

Analyses of the scale structures revealed that participants did not use the whole 6-point Likert scale. In fact, both the absolutist and the multiplist scales provoked dichotomous response patterns, whereas the evaluativist scale provoked responses on a 3-point scale. This is an interesting finding, because the items were formulated in a pronounced way (i.e., no use of words and phases such as ósometimesô, ón most casesô, and ócoftenô) so as to prompt participants to express possible nuances in their responses. The absolutist scale was the most difficult to endorse, whereas the evaluativist scale was relatively easy to endorse, and might even reflect more socially desirable responses. In fact, compared to studies using other stage models, the high school students in the present study were far more evaluativist than the average college student in these other studies (e.g., King & Kitchener, 2002). However, previous studies were conducted in the 1970s and 1980s, and cultural differences are likely. On the other hand, the standard deviation of the evaluative scale is fairly large, which might indicate that the persons are in a transition stage regarding their epistemic beliefs. As a matter of fact, previous work has indicated that students from senior years in secondary school increasingly hold predominantly evaluativist epistemic beliefs with regard to knowledge claims on social and physical truth (Kuhn et al., 2000).

Implications
The instrument described in this paper provides a first step toward accurate measures of epistemic beliefs that can distinguish between sophisticated and less sophisticated beliefs. Future development of the instrument will focus on filling the gaps items that constitute the separate dimensions. In particular, the evaluativist scale needs items that are more difficult to endorse, whereas the absolutist scale needs items that are easier to endorse. In its current form, the multiplist scale can already sufficiently distinguish between high and low multiplist students, and the evaluativist scale comes close. The absolutist scale requires more effort, but it can be argued that this may be due to the population used in this study, which is very likely beyond the absolutist stage (cf. Kuhn, 1999). This makes it difficult for these student to endorse such items. Therefore, future work should be directed at studying epistemic beliefs in groups that are more heterogeneous regarding their epistemic beliefs than the

groups participating in the present study. In addition, the instrument will be included in empirical studies on information processing to investigate whether epistemic beliefs are determinants of such processing.

References

Bond, T. G., & Fox, C. M. (2007). *Applying the Rasch model. Fundamental measurement in the human sciences.* Mahwah, NJ: Lawrence Erlbaum Associates.

Bråten, I., Strømsø, H. I., & Samuelstuen, M. S. (2008). Are sophisticated students always better? The role of topic-specific personal epistemology in the understanding of multiple expository texts. *Contemporary Educational Psychology, 33*, 814ï 840.

Bromme, R., Kienhues, D., & Stahl, E. (2008). Knowledge and epistemological beliefs: An intimate but complicate relationship. In M. S. Khine (Ed.), *Knowing, knowledge and beliefs* (pp. 423-441). New York, NY: Springer.

Clarebout, G., Elen, J., Luyten, L., & Bamps, H. (2001). Assessing epistemological beliefs: Schommerôs questionnaire revisited. *Educational Research and Evaluation, 7*(1), 53ï 77.

Conley, A., Pintrich, P., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology, 29*, 186-204.

DeBacker, T. K., Crowson, H. M., Beesley, A. D., Thoma, S. J., & Hestevold, N. L. (2008). The challenge of measuring epistemic beliefs: an analysis of three self-report instruments. *The Journal of Experimental Education, 76,* 281ï 312.

Duell, O. K., & Schommer-Aikins, M. (2001). Measures of peopleôs beliefs about knowledge and learning. *Educational Psychology Review, 13*, 419ï 449.

Elby, A., & Hammer, D. (2001). On the substance of a sophisticated epistemology. *Science Education, 85,* 554ï 567.

Hofer, B. K. (2004). Epistemological understanding as a metacognitive process: Thinking aloud during online searching. *Educational Psychologist, 39,* 43ï 55.

Hofer, B. K, & Pintrich, P. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67,* 88-140.

King, P. M., & Kitchener, K. S. (2002). The reflective judgment model: Twenty years of research on epistemic cognition. In B. K. Hofer, & P. R. Pintrich (Eds.), Personal epistemology: The psychology of beliefs about knowledge and knowing (pp. 37ï 61). Mahwah, NJ: Lawrence Erlbaum Associates.

Kuhn, D. (1991). *The skills of argument.* Cambridge, UK: Cambridge University Press.

Kuhn, D. (1999). A developmental model of critical thinking. *Educational Researcher, 28,* 16-25.

Kuhn, D., Cheney, R., & Weinstock, M. (2000). The development of epistemological understanding. *Cognitive Development, 15,* 309ï 328.

Linacre, J. M. (2009a). Winsteps® (Version 3.69.0). [Computer Software]. Beaverton, OR: Winsteps.com.

Linacre, J. M. (2009b). A user's guide to Winsteps Ministeps Rasch model computer programs. Retrieved from www.winsteps.com/winpass.htm

Muis, K. R. (2007). The role of epistemic beliefs in self-regulated learning. *Educational Psychologist, 42*(3), 173ï 190.

Nussbaum, E.M., Sinatra, G.M., & Poliquin, A. (2008). Role of epistemic beliefs and scientific argumentation in science learning. *International Journal of Science Education, 30*(15), 1977ï 1999.

Rasch, G. (1960). *Probabilistic models for some intelligence and attainment tests.* Chicago, IL: University of Chicago Press.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology, 82,* 498ï 504.

Schraw, G., Bendixen, L. D., & Dunkle, M. E. (2002). Development and validation of the Epistemic Belief Inventory. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 103ï 118). Mahwah, NJ: Lawrence Erlbaum Associates.

Wood, P., & Kardash, C. (2002). Critical elements in the design and analysis of studies of epistemology. In B. K. Hofer & P. R. Pintrich (Eds.), *Personal epistemology: The psychology of beliefs about knowledge and knowing* (pp. 231ï 260). Mahwah, NJ: Lawrence Erlbaum Associates.